

Repolarization characteristics and incidence of Torsades de Pointes in patients with acquired complete atrioventricular block

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ABSTRACT

Objective: Torsades de pointes (TdP) during bradyarrhythmias have been reported to be associated with gender, degree of QT prolongation and duration of bradyarrhythmia. We sought to investigate the repolarization characteristics on 12-lead electrocardiogram (ECG) and the incidence of TdP in patients with acquired complete atrioventricular block (CAVB).

Methods: Fifty consecutive patients with acquired CAVB were included in the study. Patients with coronary artery disease, systolic dysfunction and previous cardiac surgery were excluded. Patients were monitored during hospitalization for ventricular arrhythmias (VA). Serum potassium, magnesium, calcium levels and thyroid-stimulating hormone were measured. Heart rate, QRS duration, QT/QTc, JT/JTc and Tpeak-Tend intervals were measured. Pathologic U waves, T-U complex, and QT morphologies were remarked.

Results: Patients presented with presyncope (n=39, 78%), syncope (n=12, 24%), and palpitations (n=8, 16%). All patients were in sinus rhythm. Duration of CAVB was 8.5 days (median). Patients were divided into two groups based on JT interval. Group 1 (JT \geq 500 ms, n=13) tended to have more female patients and more VAs in comparison to Group 2 (JT<500 ms, n=37). Group 1 patients had more pathologic U waves and T-U complexes, longer Tpeak-Tend intervals, and more long QT2 syndrome (LQT2)-like QT morphology in comparison to Group 2 patients. Group 2 patients had more often syncope. One patient in Group 2 developed ventricular fibrillation in the presence of hypokalemia and hypomagnesemia.

Conclusion: Torsades de Pointes during CAVB was rare among our patient population. The predictors of VA during CAVB were presence of prolonged QTc/JTc intervals, pathologic U wave and T-U complex, prolonged Tpeak-Tend interval, and LQT2-like QT morphology. (*Anadolu Kardiyol Derg 2007; 7 Suppl 1; 98-100*)

Key words: Torsade de Pointes, heart block, repolarization, QT interval, JT interval

Introduction

Bradyarrhythmias, including complete atrioventricular block (CAVB), may predispose to acquired long-QT syndrome (LQTS) and torsade de pointes (TdP) (1). Torsades de Pointes (TdP) was first described in a patient with acquired CAVB (2). Between 5% to 30% of patients with CAVB have been reported to develop TdP (3). Kurita et al. (4) have reported that patients with bradycardia-induced TdP have abnormally long QT intervals at slow heart rates, compared with patients with bradycardia but no tachyarrhythmia. Moroe et al (5) have reported that in patients with CAVB associated with prolonged QTc interval frequent ventricular premature beats might induce TdP. Also Strasberg et al. (6) have reported that QT interval above 600 ms and premature ventricular beats on electrocardiogram (ECG) seem to indicate an increased risk for the development of polymorphic ventricular tachycardia in a patient with atrioventricular block (AVB) (6). In addition, increased propensity of women to develop TdP during CAVB has been reported (7).

In vivo studies showed that the duration of AVB is an important determinant of the susceptibility to acquired TdP, because the TdPs are rarely inducible at 0 weeks of AVB (acute AVB) or at sinus rhythm but are readily inducible at \geq 5 weeks (chronic AVB) in most animals (8). The increased susceptibility to arrhythmias in chronic AVB has been related to an inhomogeneous prolongation of the monophasic ventricular action potential (more in the left ventricle than the right ventricle), leading to enhanced regional dispersion of repolarization (8). We sought to investigate the repolarization characteristics on 12-lead ECG and the incidence of TdP in patients with acquired CAVB.

Methods

Study Population

Seventy two consecutive patients presenting with acquired CAVB were retrospectively included in the study, between January 2001 and December 2006. Patients with acute coronary syndrome, history of coronary artery disease, left ventricular systolic dysfunction (left ventricular ejection fraction <50%), congenital CAVB, and previous cardiac surgery were excluded (n=22). The remaining 50 patients formed the study population.

Data Acquisition

Every patient had 12-lead ECGs before the permanent/temporary pacemaker implantation. All patients had serial serum creatine kinase-MB and cardiac troponin I measurements. Serum potassium, magnesium, calcium levels and thyroid-stimulating hormone were measured in all patients.

Measurements

The 12-lead ECGs were recorded at standard gain (10 mV/mm) and speed (25 mm/s). Heart rate, QRS duration, QT and corrected QT (QTc) intervals, JT and corrected JT (JTc) intervals, Tpeak-Tend intervals were measured. Cardiac rhythm, presence or absence of pathologic U wave or T-U complex, QT morphologies, inverted T waves (>3mV), intraventricular conduction disturbances, frequent ventricular premature contractions (PVC) (≥ 10/hour), couplets and ventricular tachycardias (VT) were remarked.

The QT interval was measured from the onset of the QRS interval to the end of the T wave in all the leads where the end of the T wave could be clearly defined. The JT interval was derived by subtracting the QRS duration from the QT interval. The QT and JT intervals were corrected for the heart rate using the Bazett formula (QTc and JTc) (9). Pathologic U wave was defined as U wave with an amplitude of greater than 25% of the of T wave. T-U complex was defined as two contiguous repolarization waves, the first being T wave and the second being U wave (10, 11). Tpeak-Tend was the interval from the summit of the T wave to the end of the QT interval. T wave morphology was defined as in the congenital Long QT syndrome (LQTS): 1) "LQT1-like morphology" denoted a long QT interval (QTc interval ≥450 ms) with broad T waves; 2) "LQT2-like morphology" denoted a long QT interval with double (notched) T waves; and 3) "LQT3-like morphology" denoted a long QT interval with small T waves separated from the QRS interval by a long isoelectric ST-segment (12, 13). Torsades de pointes was defined as a ventricular tachycardia (rate>than 150 beats/min and lasting ≥5 beats) that originated from the terminal part of the QT interval and had a polymorphic configuration (13). Intraventricular conduction disturbances were defined as previously described (14). Measurements were made with caliper in leads with longest QT interval.

Previous studies advocated the use of JT interval instead of the QT interval as a result of secondary prolongation of the QT interval due to prolonged excitation time in ventricular conduction defects. Since significant number of patients in our study had intraventricular conduction delay, we used JT and JTc intervals rather than QT and QTc intervals for the evaluation of the repolarization.

Transthoracic echocardiography

All patients underwent transthoracic echocardiography for the measurements of right and left ventricular ejection fractions, right and left ventricular wall thicknesses, and end-systolic/diastolic chamber diameters.

Statistical Analysis

Values were expressed as mean±SD. Characteristics of groups were compared using the unpaired Student's t-test and p<0.05 was considered as statistically significant. Categorical variables were compared using Chi-square analysis.

Results

Study population consisted of 50 patients (30 women/20 men; mean age 75±10 years, range 46 to 92). Patients presented with

presyncope (n=39, 78%), syncope (n=12, 24%), and palpitations (n=8, 16%). All patients were in sinus rhythm. Intraventricular conduction delay was observed in 31 (62%) patients. Duration of CAVB was 8.5 days (median).

Study population was divided into two groups based on JT interval. Characteristics of Group 1 (JT≥ 500 ms, n=13) and Group 2 (JT< 500 ms, n=37) patients are summarized in Table 1.

Group 1 patients tended to have more female patients and more ventricular arrhythmias in comparison to Group 2 patients. Group 1 patients had more pathologic U waves and T-U complexes (p=0.0001), longer Tpeak-Tend intervals (p<0.0001), and more LQT2-like QT morphology (p=0.005) in comparison to Group 2 patients. Group 2 patients had more episodes of syncope (p>0.05). There were two patients taking "possible" QT prolonging agents in Group 2. One patient in Group 2 developed ventricular fibrillation in the presence of hypokalemia and hypomagnesemia. This patient presented with presyncope and had QTc of 480 ms and JTc of 360 ms.

Discussion

Complete AVB may lead to downregulation of potassium channels, QT interval prolongation, and TdP (15, 16). Episodes of TdP may result in syncope, cardiac arrest, and even death due to degeneration into ventricular fibrillation. Also, repolarization changes secondary to CAVB may indicate underlying potassium channelopathies (mutations and polymorphisms) (17). Therefore, identification of patients at risk of developing TdP and cardiac

Table 1. Clinical and electrocardiographic characteristics of patients

Variables	Group 1	Group 2	p
Age, years	76±9	75±10	NS
Gender, Female/Male	9/13	21/37	NS
Presence of syncope, n (%)	1(7)	11(30)	NS
Duration of AV block, days*	10	7	NS
Presence of VA, n (%)	2(15)	2(5)	NS
Presence of LVH, n (%)	5(38)	10(27)	NS
RR interval, ms	1660±300	1610±260	NS
QRS duration, ms	122±26	136±31	NS
QT, ms	677±41	545±59	<0.0001
QTc, ms	529±45	431±41	<0.0001
JT, ms	555±37	409±52	<0.0001
JTc, ms	434±42	324±36	<0.0001
Tpeak-Tend, ms	268±75	146±43	<0.0001
U wave/T-U complex, n (%)	8 (62)	3(8)	<0.0001
Serum potassium, mEq/l	4.2±0.6	4.4±0.7	NS
QT prolonging agent, n (%)	0	2 (5)	NS
LQT1-like QT morphology, n (%)	3(23)	8(22)	NS
LQT2-like QT morphology, n (%)	7(54)	3(8)	0.005
LQT3-like QT morphology, n (%)	1(8)	0	NS

Data are given as mean±SD, number of patients, percentages, and *median. p<0.05 considered to be significant.
 AV- atrioventricular, LQT- long QT syndrome, LVH- left ventricular hypertrophy, NS- non significant, VA- ventricular arrhythmia (premature ventricular contraction, couplet, ventricular tachycardia and ventricular fibrillation)

events is crucial. For this purpose new risk factors such as Tpeak-Tend interval and LQT2-like notched T waves have been described recently. In our study, patients with prolonged QTc and JTc intervals had more pathologic U wave and T-U complex and LQT2-like notched T waves.

The rarity of TdP in our study population can be partly explained by genetic composition of Turkish population. Chevalier et al. (17) recently described HERG mutations in 17% of patients presenting with CAVB and prolonged QT interval (>600 ms) in a French population. None of the patients with CAVB and shorter QT interval (<600 ms) had HERG mutations. These mutations may not be common in Turkish population. As a result, further studies are needed for identification of genetic risk factors in this group of patients.

Roden et al. (18) have suggested that the extent of QT lengthening in response to specific environmental triggers depends on the "ventricular repolarization reserve". As a consequence, under baseline conditions, mutations in genes controlling normal repolarization may remain subclinical and may only be the source of clinical and electrocardiographic manifestations of the LQTS upon exposure to further stressors, such as drugs or bradycardia. Low incidence of QT prolonging drug use, normal serum potassium levels, and genetic background may explain the rarity of TdP in our study population.

Study Limitations

Genotype analysis was not performed for LQTS genes in our patients.

Conclusions

Torsades de pointes during CAVB was rare among our patient population. The predictors of ventricular arrhythmia during CAVB were presence of prolonged QTc/JTc intervals, pathologic U wave and T-U complex, prolonged Tpeak-Tend interval, and LQT2-like QT morphology.

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